

Equations and Constants for the Fall 2001 SP 211 Final Exam

This formula sheet consists mostly of equations from the Summary section at the end of each chapter. You may print out these equations on one sheet of paper. (Yes, you will probably need to run it through your printer twice in order to get one page on the front and the other on the back). You may write anything that you like on it and use it during the final exam.

$$\bar{v} = \frac{\Delta x}{\Delta t} \quad \bar{v} = \frac{\Delta \mathbf{r}}{\Delta t} \quad (\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k})$$

$$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \quad \mathbf{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \mathbf{r}}{\Delta t} = \frac{d\mathbf{r}}{dt} \quad (\mathbf{v} = v_x\mathbf{i} + v_y\mathbf{j} + v_z\mathbf{k})$$

$$\bar{a} = \frac{\Delta v}{\Delta t} \quad \bar{\mathbf{a}} = \frac{\Delta \mathbf{v}}{\Delta t}$$

$$a = \lim_{\Delta t \rightarrow 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} \quad \mathbf{a} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \mathbf{v}}{\Delta t} = \frac{d\mathbf{v}}{dt} \quad (\mathbf{a} = a_x\mathbf{i} + a_y\mathbf{j} + a_z\mathbf{k})$$

$$v = v_o + at$$

$$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + \frac{1}{2} \mathbf{a} t^2$$

$$v^2 = v_0^2 + 2a(x - x_0) \quad (\text{For vector } \mathbf{r}, r = \sqrt{x^2 + y^2 + z^2}, \tan \theta = \frac{y}{x})$$

$$a_R = \frac{v^2}{r} \quad \sum \mathbf{F} = m\mathbf{a} \quad \mathbf{F}_G = m\mathbf{g} \quad F_{fr} = \mu_k F_N \quad F_{fr} \leq \mu_s F_N \quad g = 9.8 \text{m/s}^2$$

$$F_R = ma_R = m \frac{v^2}{r} \quad F_{grav.} = G \frac{m_1 m_2}{r^2} \quad F_s = -kx \quad G = 6.67 \times 10^{-11} \text{ N-m}^2/\text{kg}^2$$

$$T^2 = \left(\frac{4\pi^2}{GM_s} \right) r^3 \quad W = Fd \cos \theta = \mathbf{F} \bullet \mathbf{d} \quad W = \int_a^b \mathbf{F} \bullet d\mathbf{l} = \int_a^b F \cos \theta dl$$

$$K = \frac{1}{2} mv^2 \quad W_{net} = \Delta K = K_2 - K_1 \quad \Delta U = U_2 - U_1 = - \int_1^2 \mathbf{F} \bullet d\mathbf{l}$$

$$U_G = mg y \quad U_{spring} = \frac{1}{2} kx^2 \quad U_{grav.} = -G \frac{m_1 m_2}{r}$$

$$E = K + U = const. \quad E = \frac{1}{2} mv^2 - \frac{GMm}{r} \quad v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$\bar{P} = \frac{W}{t} \quad P = \frac{dW}{dt} = \frac{dE}{dt} = \mathbf{F} \bullet \mathbf{v}$$

$$\mathbf{p} = m\mathbf{v} \quad \sum \mathbf{F} = \frac{d\mathbf{p}}{dt} \quad \mathbf{J} = \int_{t_i}^{t_f} \mathbf{F} dt = \mathbf{p}_f - \mathbf{p}_i$$

$$\mathbf{P} = \mathbf{p}_1 + \mathbf{p}_2 + \dots = m_1 \mathbf{v}_1 + m_2 \mathbf{v}_2 \dots$$

$$\mathbf{r}_{cm} = \frac{\sum m_i \mathbf{r}_i}{M} \quad \mathbf{v}_{cm} = \frac{\sum m_i \mathbf{v}_i}{M} \quad \mathbf{P} = M \mathbf{v}_{CM} \quad \sum \mathbf{F}_{ext} = M \mathbf{a}_{cm} = \frac{d\mathbf{P}}{dt}$$

$$\begin{aligned}\omega &= \frac{d\theta}{dt} & v &= R\omega \\ \alpha &= \frac{d\omega}{dt} & a_{tan} &= R\alpha \quad a_R = \omega^2 R \\ \omega &= \omega_o + \alpha t \quad \theta = \theta_o + \omega_o t + \frac{1}{2}\alpha t^2 \quad \omega^2 &= \omega_o^2 + 2\alpha(\theta - \theta_o)\end{aligned}$$

$$\tau = R_\perp F = RF_\perp = RF \sin \theta \text{ (or, } \tau = \mathbf{r} \times \mathbf{F}) \quad \sum \tau = I\alpha = \frac{dL}{dt}$$

$$I = \sum m_i R_i^2 = \int R^2 dm = I_{CM} + Mh^2 \quad L = I\omega$$

$$K = \frac{1}{2} I \omega^2 \quad K_{rolling} = \frac{1}{2} M v_{CM}^2 + \frac{1}{2} I_{CM} \omega^2$$

$$P = \frac{F}{A} \quad \rho = \frac{m}{V} \quad P = P_o + \rho gh \quad Av = const. \quad P + \frac{1}{2} \rho v^2 + \rho gy = const.$$

$$f = \frac{1}{T} \quad T = 2\pi \sqrt{\frac{m}{k}} \quad \omega = 2\pi f = \sqrt{\frac{k}{m}} \quad x = A \cos(\omega t + \phi)$$

$$E = \frac{1}{2} mv^2 + \frac{1}{2} kx^2 = \frac{1}{2} kA^2 \quad T = 2\pi \sqrt{\frac{L}{g}} \quad T = 2\pi \sqrt{\frac{I}{mgh}}$$

$$x = A e^{-\alpha t} \cos \omega' t$$

$$v = \lambda f \quad D(x, t) = D_M \sin(kx - \omega t) \quad k = \frac{2\pi}{\lambda} \quad \omega = 2\pi f$$

$$D = 2D_M \sin kx \cos \omega t \quad v = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = n \frac{v}{2L} (n=1,2,3\dots) \quad f_n = n \frac{v}{4L} (n=1,3,5\dots)$$

$$f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right) \quad P = \frac{1}{2} \mu \omega^2 A^2 v \quad R = \frac{1}{2} D \rho A v^2 \quad v_t = \sqrt{\frac{2mg}{D \rho A}}$$